

Near Infrared Camera

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- Near infrared (NIR) photometry is essential to the accurate SN distance measurements required for the core science mission.
 - Supernova emission redshifted into IR even at moderate z : Si II (6250 Å) line \rightarrow 1 μm at $z=0.6$
 - Supernova photometry must be done at a common rest-frame wavelength in order to suppress systematic errors.
 - NIR photometry is essential to the diagnosis and correction of systematic errors due to extinction by intervening dust clouds, as all known forms of dust have much lower extinction in the NIR than in the visible.
- Wide-field NIR option expands science capabilities.
 - Independent SNe discovery
 - Possibility of unprecedented deep NIR survey (many science benefits)
 - Faster follow-up observations

Wide-field NIR Survey Science Reach



- Photometric redshifts of Galaxies to $z=2.5$
 - Evolution of the Galaxy luminosity function
 - Evolution of star formation rate
 - Discovery of high- z galaxy clusters
- Lensing measurements
 - Use cosmic shear to measure mass power spectrum
 - Photo- z permits isolation of sheets of background galaxies
 - Compare individual sheets to measure evolution of dark matter power spectrum
 - Shear map provides constraints on possible SNe magnification
- Discovery of high-redshift quasars
 - At $z=7.2$ Ly- α passes $1\mu\text{m}$
 - Uncover epoch of re-ionization, probe quasar evolution
 - Probe far down QSO/AGN luminosity function
 - QSO photoz
- Study of L and T Dwarfs throughout the disk
 - $M_z \approx 19$; observations to 29 can observe these to 1 kpc
- Provide targets for NGST spectroscopy
- Study optical components of gamma-ray bursts

Science Driven Requirements



Field of View	$> 1 \text{ arcmin}^2$	to include reference stars & increase survey efficiency
Plate Scale	0.08 - 0.12 arcsec / pixel	to achieve photometric accuracy with dithering
Detector Type Wavelength Coverage	HgCdTe 1.0 μm - 1.7 μm	HgCdTe device with 1.7 μm cut-off allows passive thermal control
Detector Temperature	130 -140 K	to achieve dark current
Read Noise Dark Current	5 e^- (multiple samples) 0.05 e^-/sec	Assures that photometry is zodiacal light limited
Quantum Efficiency (Detector)	$\sim 70\%$	to achieve adequate S/N to study SNe at $z=1.7$
Photometric Accuracy	1% relative	ensures statistics limited distance measurement
Filters	J&H, and five special filters	to obtain redshifted V-band steps from 1 to 1.7 μm

NIR Camera Options



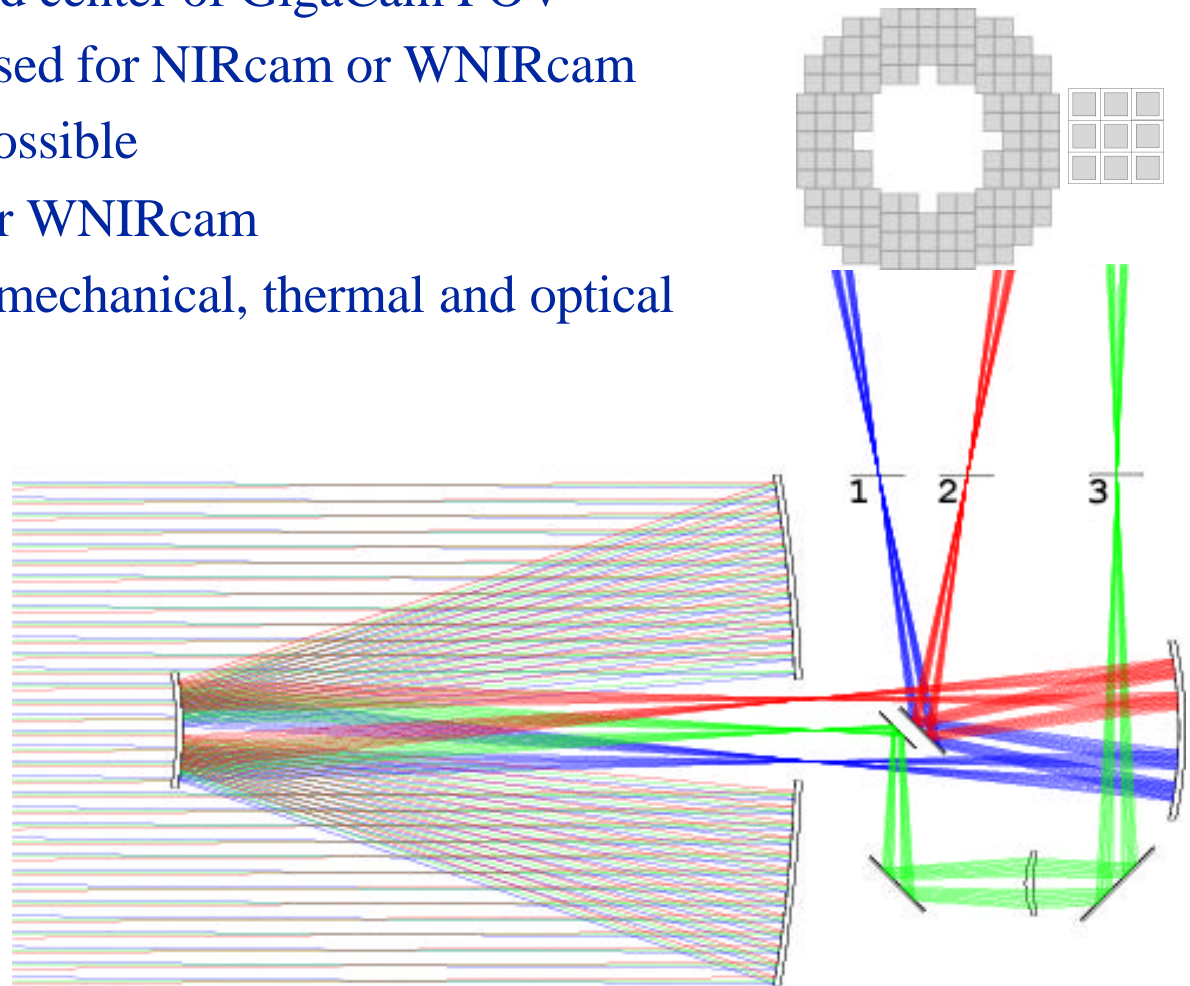
- Baseline NIRcam
- Wide-field NIR camera (WNIRcam)
- WNIRcam as Fully Integrated Detector Option (FIDO)

	NIRcam	WNIRcam	WNIRcam-FIDO
Detector Type	HgCdTe (1k x 1k)	HgCdTe (2k x 2k)	HgCdTe (1k x 1k)
FOV	small: 0.0005 deg ² (1.4' x 1.4')	wide: 0.024 deg ² (9' x 9')	wide: 0.028 deg ² annulus
Plate Scale	0.08 arcsec/pixel	0.09 arcsec/pixel	0.12 arcsec/pixel
No. of Detectors	1	9	24
Thermal Enclosure	separate	separate	integrated
Additional Optics	required	required	not required
On-detector Guiding	no	yes	no

NIR Camera Optics Concept (separate focal plane)

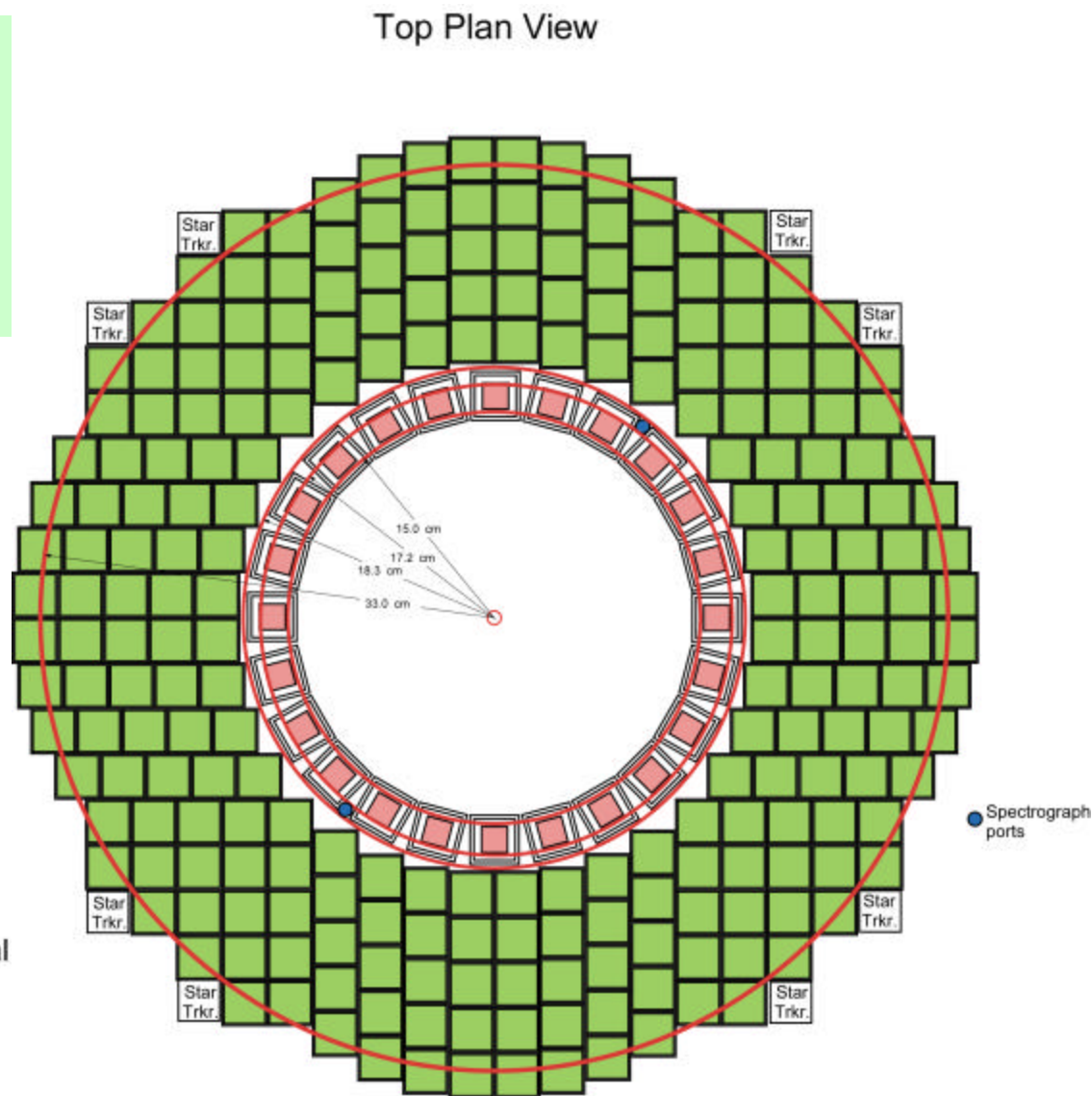
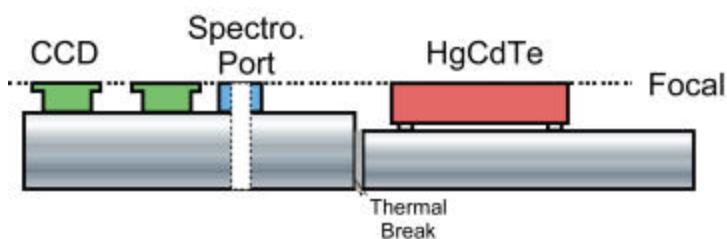


- Separate focal plane for NIR camera requires fold and re-imaging optics
- Pick-off mirror in unused center of GigaCam FOV
- Optics concept can be used for NIRcam or WNIRcam
- Independent dithering possible
- Self-guiding possible for WNIRcam
- Drawback: challenging mechanical, thermal and optical design
- WNIRcam allows multiplexed NIR discovery and follow-up of $z > 1.2$ SNe in parallel with GigaCam program



Field of View	0.028 sq. deg.
Plate Scale	0.12 arcsec/pixel
Detectors	24 (1k x 1k)
Architecture	annulus

- Integrated focal plane reduces complexity of mechanical, thermal and optical design
- Annular geometry optimized for follow-up observations



Angles
5.00 mrad
5.73 mrad
6.10 mrad
11.00 mrad

CCD (10.5 nm)
236
0.07 asec
0.86 sq. deg.

HgCdTe
24
0.123 asec
0.029 sq. deg.

Main R&D Issues

- Trade Studies to decide on NIR camera configuration
- Optimization of planned SNe observation and follow-up in NIR
- Study intra-pixel variations and establish impact on accurate photometry
- Thermal background on detector
- Develop mechanical and optical concept for NIR imager
- Optimize calibration techniques and strategies
- Establish facility for receiving and qualifying NIR FPAs
- Following developments of 1.7 μm FPA for WFC3 and 1.9 μm FPA for VIRMOS

Technical Challenges

- Obtain 1% relative photometric accuracy in under-sampled regime by optimizing dithering pattern
- Reduce thermal background from mirrors and baffles below zodiacal light level
- Produce stable mechanical design for second focal plane option
- Develop guiding scheme for second focal plane option
- Develop plan for testing and calibration program to identify and eliminate problems that could jeopardize the SNAP science goals

Commonality with NGST & WFC3 R&D



- Many of the critical measurements needed to design the NIR camera for SNAP are being planned by NGST: dark current, read noise, gain, linearity, persistence, QE, MTF, intra-pixel sensitivity, radiation and temperature effects
- To the extent possible we will develop cooperative programs that will take advantage of NGST, WFC3, and VIRMOS R&D needs that are common to the SNAP mission
- Although NGST and WFC3 science objectives result in many common science requirements, there are significant differences:

	SNAP	NGST DRM	WFC3
# Pixels	> 1 M	64 M	1 M
Detector Type	HgCdTe	HgCdTe or InSb	HgCdTe
Wavelength Coverage	1.0 μ m - 1.7 μ m	1 μ m - 5 μ m	1 μ m - 1.8 μ m
Detector Temperature	130 -140 K	30 K	150 K
Read Noise	5e ⁻ (multiple samples)	~ 7e ⁻ (multiple samples)	~ 15 e ⁻
Dark Current	0.05 e ⁻ /sec	0.05 e ⁻ /sec	0.4 e ⁻ /sec
Quantum Efficiency	70%	> 80%	
Photometric Accuracy	1% relative	1% relative	
Diffraction Limited Imaging	no	yes	no

Trade Studies



Scientific Trade Study

Scheduling of planned supernova follow-up program
Supernova discovery and follow-up with a wide-field NIR camera
Impact on SNAP systematic errors
Auxiliary science benefits of a wide-field NIR deep survey

Technical Trade Study

Pixel scale/sampling/photometry	Guiding for the NIR focal plane
Thermal requirements	Power requirements
Detector performance and availability	Mass estimate
Optical design	Data handling requirements
Cold stop or OTA emissivity requirements	Compression and data handling
Filter mechanical/electronic design	Fallback options
System optical throughput	

Summary



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- Early R&D for NIR camera is required for successful SNAP mission
 - Scientific and technical trade studies and cost will drive the selection of the optimal NIR camera.
 - Prototype tests of an NIR FPA will optimize operational parameters, provide input to design efforts and will establish a facility within the SNAP collaboration to receive and qualify FPAs.
 - Parallel thermal, mechanical, optical and electronic design efforts will culminate in a conceptual design, cost plan and schedule for the NIR camera in time for the conceptual design review.